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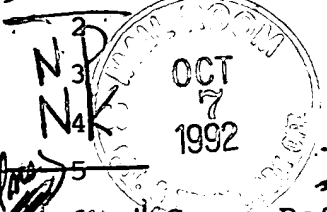
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MAGNETIC HEAD SUSPENSION ASSEMBLY
FABRICATED WITH INTEGRAL LOAD BEAM AND FLEXURE

CL17UC Cross-Reference to Copending Application

7 PFB Copending U.S. patent application Serial Number 07/926,033
8 FB filed August 5, 1992 is directed to a head suspension assembly
9 particularly useful with nanosliders, which are about 50% of the
10 size of the standard full size air bearing sliders. The present
11 application discloses a modified and improved head suspension
12 assembly especially useful with femtosliders, which are about 25%
13 of the size of the standard full size sliders. The subject
14 matter of the aforementioned copending application is
15 incorporated herein by reference.

CL17UC Field of the Invention

18 P This invention relates to a magnetic head suspension assembly
19 that accommodates air bearing femtosliders which are used in
20 compact disk drives.

CL22UC Description of the Prior Art

23 P Presently known disk drives, such as used in laptop or notebook
24 computers, include at least one rotatable magnetic disk, at least
25 one magnetic head assembly for transducing data recorded on the
26 disk, and a rotary head actuator for transporting the magnetic
27 head to selected data tracks on the rotating disk. The magnetic
28 head assembly comprises a head suspension fabricated with a rigid
29 load beam element and a gimbaling flexure. A typical head
30 suspension includes a load beam element and a flexure which are
31 fabricated as separate parts and are then joined during assembly
32 of the head suspension. Special tooling to implement accurate
33 alignment and assembly of the load beam and flexure is required.
34 After joinder of the load beam element and flexure, an air
35 bearing slider is mounted at the end of the flexure. The slider
36 supports a thin film magnetic transducer which coacts with the
37 magnetic disk for recording or reading data signals.

1 P During operation of the disk drive, the rotating magnetic disk
2 provides an aerodynamic lift force to the slider, while an
3 opposing gram load force is applied to the slider through the
4 flexure. The resultant of the two opposing forces determines the
5 flying height of the slider and its transducer relative to the
6 disk surface. In its operating flying mode, the slider gimbals
7 about a load dimple formed in the flexure.

8
9 In known prior art head suspension and flexure designs, the load
10 force transfer and gimbaling action are separate to provide high
11 first bending frequency with low pitch and low stiffness. The
12 flexure participates slightly in the load transfer with the load
13 beam while primarily providing the low pitch and roll stiffness
14 gimbaling action and providing high stiffness for lateral motion.
15 These suspensions are characterized by weak pitch, roll and
16 bending stiffness when the head is flying over the disk surface.
17 For optimum functioning, however, the suspension structure should
18 provide a high first bending mode resonant frequency so that the
19 slider can follow variations in the topography of the rotating
20 disk surface while providing low pitch and roll stiffness.

21
22 Another objective in the design of compact disk drives which are
23 used in laptop or notebook computers is to minimize the size and
24 mass of the drive components. A reduction in Z-height (vertical
25 height) of the suspension and slider assembly results in a
26 corresponding reduction in the Z-height of the compact disk drive
27 incorporating the assembly. A standard full size slider is about
28 B 0.160 inch long, 0.125 inch wide and 0.0345 inch high. Presently
29 known disk drives employ nanosliders that measure approximately
30 B 0.080 inch long, 0.063 inch wide and 0.017 inch high, which size
31 B is about 50% of the size of a standard slider. The novel
32 suspension and slider design disclosed herein is particularly
33 useful for femtosliders, which measure about 0.040 inch long,
34 B 0.020-0.026 inch wide and 0.0110 inch in overall height, which
35 B size is about 25% of the size of a standard full size slider. It

1 should be understood that the novel design may be used with other
2 size sliders as well.

3
CLMK P Summary of the Invention

5 An object of this invention is to provide a head suspension and
6 slider assembly having significantly reduced Z-height.

7
8 Another object of this invention is to provide a head suspension
9 assembly characterized by low pitch and roll stiffness.

10
11 Another object is to provide a head suspension assembly
12 characterized by low bending stiffness with decreased gram load
13 tolerance effects.

14
15 Another object is to provide a head suspension assembly
16 characterized by a relatively high first bending mode, first
17 torsion mode, and first lateral mode resonant frequencies.

18
19 A further object is to provide a head suspension design that
20 affords significant savings and advantages in manufacture and
21 mass production.

22
23 According to this invention, a magnetic head suspension assembly
24 is formed from an integral planar piece comprising a load beam
25 section and flexure section. The load beam is configured
26 preferably as a truncated conical section having flanges along
27 its sides and an extending tongue at its narrow end. The side
28 flanges are formed with U-shaped channels and provide rigidity
29 and stiffness to the load beam section. The load beam tongue
30 extends into the flexure section and is formed with a
31 hemispherical load dimple which faces down to the non-air bearing
32 surface of a head slider. A U-shaped cutout portion that is
33 formed in the flexure section adjacent to the load beam tongue
34 delineates the shape of the tongue. In one embodiment of the
35 invention, the flexure section includes two narrow etched legs

1 that extend from the load beam and are disposed adjacent to the
2 cutout portion. The narrow legs are connected by a lateral ear
3 at the end of the flexure. In this implementation, the head
4 slider is bonded to the bottom surface of the lateral ear. In an
5 alternative embodiment, the flexure section includes outriggers
configured as a split tongue to which the slider is bonded.

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Brief Description of the Drawings

The invention will be described in greater detail with reference to the drawings in which:

Figure 1A is a top plan view of a head suspension and slider assembly, made in accordance with this invention;

Figure 1B is a front elevational view of the head suspension of Fig. 1;

Figure 2 is a side elevation view of the assembly of Fig. 1, showing a head slider attached to the end of the flexure, in a loaded position and in phantom in an unloaded position;

Figure 3 is a bottom view of the head suspension of Fig. 1;

Figure 4 is a side elevation view of the assembly of Fig. 3, showing the load dimple without an attached slider;

Figure 5A is an enlarged view of a portion of the head suspension of Fig. 3;

Figure 5B is a front elevation view of the head suspension of Fig. 5A;

Figure 6A is an enlarged view of a portion of a head suspension and flexure incorporating an alternative design;

Figure 6B is a front elevation view of the head suspension portion of Fig. 6A;

Figure 6C is a representational front view showing the overhang of the outriggers of Fig. 6A relative to a slider;

Figure 7 is a side elevation view of a portion of the head suspension shown in Fig. 6A;

Figure 8 is a plan sectional representation of a paddle board or fret illustrating three of a multiplicity of head suspension bodies stamped from a piece of stainless steel;

1 Figure 8A is a side elevation view of the paddle board of Fig. 8;
2 Figure 9 is a top plan view of a nanosl原因 suspension, such as
3 disclosed in the aforementioned copending application;
4 Figure 10 is a top plan view of a femtoslider suspension, with an
5 extended part to enable handling during production;
6 Figure 11 is a top plan view of the femtoslider suspension of
7 Fig. 10 with a skewed configuration relative to the extension;
8 Figure 12 shows the femtoslider suspension without the extension
9 for the purpose of illustrating the relative sizes of the
10 nanosl原因 suspension and the femtoslider suspension.
11 Similar numerals refer to similar elements in the drawing.

12
DEF 4K Description of the Preferred Embodiment

14 P14 With reference to Figs. 1A-5B, a magnetic head suspension
15 assembly includes a load beam section 10, a flexure section 12, a
16 leaf spring section 56 and a rear mount section 42. The
17 suspension is formed from an integral flat piece of nonmagnetic
18 material, preferably a 300 Series type stainless steel having a
19 thickness of about 0.0012 to 0.0015 inch. As a result of using
20 an integral piece, the load beam section 10 and flexure section
21 12, as well as the leaf spring section 56 and rear mount section
22 42, are disposed substantially in a single plane. No separate
23 forming of individual load beam and flexure parts is required.
24 Therefore, no assembly steps of joining and welding are needed
25 for attaching the flexure to the load beam.

26
27 The load beam section 10 is preferably made in a truncated
28 conical or triangular shape. The load beam section has a short
29 tapered tongue 14 extending from its relatively narrow end into
30 the flexure section 12. The tongue 14 is delineated by a U-
31 shaped cutout 16 in the flexure section. The load beam tongue 14
32 provides low deflections in the direction orthogonal to the plane
33 of the load beam section and flexure section by virtue of its
34 short length and low gram load force.

1 P A constrained layer damping element 19 made of elastomer 10A
2 B about 0.002 inch thick and an overlay 10B of about 0.002 inch
3 thick stainless steel is laid down on the top surface of the
4 major section of the load beam to minimize undesirable resonances
5 of the suspension, as shown in Fig. 1. Alternatively, a similar
6 damping element 21 may be deposited on the bottom surface of the
7 load beam without interfering with the flexure 12, as shown in
8 Fig. 3.

9
10 The flexure section 12 includes narrow legs 32 that are located
11 adjacent to the sides of the U-shaped cutout 16. The flexure
12 B legs 32 are chemically etched to a thickness of about 0.0010 inch
13 for increased flexibility. The narrow legs 32 are thin and
14 relatively weak to allow the desired gimbaling action about the
15 load dimple 18 and also to allow the suspension to have low roll
16 and pitch stiffness. A lateral connecting part or ear 38 is
17 formed with the integral flat load beam and flexure to connect
18 ends of the narrow legs 32.

19
20 In this implementation of the invention, a slider 22 is bonded to
21 the lateral connecting part 38. A hemispherical load dimple 18
22 is formed on the load beam tongue 14 and is in contact with the
23 top non-air bearing surface of an air bearing slider 22 that is
24 bonded to the lateral part or ear 38. The load dimple 18 is
25 formed so that the hemisphere of the dimple faces down to the
26 B/H slider. The dimple 18 may be offset, 0-0.006 inch for example,
27 from the centerline of the slider in order to control flying
28 height characteristics.

29
30 U-shaped flanges 24 extend along the sides of the load beam
31 section and are truncated before reaching the flexure section 12.
32 The flanges 24 contribute to the stiffness of the load beam
33 section and localizes the bending action to the spring section
34 56, thereby minimizing the pitch attitude changes due to arm/disk
35 vertical tolerances. Head circuitry wiring 92 without the

1 conventional tubing is located within the channels of the flanges
2 24. The absence of tubing allows the U-shaped channels of the
3 flanges 24 to be relatively shallow thereby contributing to the
4 reduction of the Z-height of the head suspension assembly.
5 Adhesive material 90 is used to maintain the wiring 92 fixed in
6 place. Adhesive fillets 91 are provided adjacent to the ear 38
7 and the slider 22. The fillets 91 are exposed and thus can be
8 cured easily by application of ultraviolet radiation.

9
10 In a disk drive using this head suspension and slider assembly,
11 flexing occurs between the load beam tongue 14 and the flexure
12 legs 32. With this design, the load force is transferred through
13 the tongue 14 to the truncated conical section of the load beam.
14 This integral load beam/flexure configuration allows the
15 separation of the applied load transfer force from the gimbal
16 action so that the structure may be made stiff at the load beam
17 for proper bending and relatively weak about the load dimple to
18 allow proper pitch and roll of the slider.

19
20 A feature of the head suspension and slider assembly disclosed
21 herein is that the slider 22 is configured with a step 28, which
22 is formed by cutting a recessed portion or platform 30 on the
23 non-air bearing top surface of the slider 22. The Z-height of
24 the step 28 is substantially the same as the Z-height of the
25 hemispherical load dimple 18. Sufficient spacing is provided
26 between the load beam tongue 14 and the top slider surface to
27 allow free gimbaling action of the slider 22 with no interference
28 from the load beam. The slider step 28 is sufficiently high so
29 that the slider end at the trailing edge can accommodate a thin
30 film magnetic transducer including its coil turns.

31
32 The leaf spring 56 between the load beam section 10 and the rear
33 mount section 42 is formed with a trapezoidal-like cutout 60 to
34 provide flexibility. The flexible section 56 is formed to
35 provide a desired load force that counteracts the aerodynamic

1 lift force generated by the rotating disk during operation of the
2 disk drive. The load force arises from bending the suspension
3 from the phantom position, shown in Fig. 2, to the raised
4 position as indicated by the arrow.

5
6 The rear mount section 42 of the load beam 10 has a hole 48 to
7 allow connection of a swage plate 46 to the suspension by means
8 of a boss 48 and by laser welding. The swage plate 46 provides
9 stiffness to the rear mount section 42. Rear flanges 54 provide
10 wire routing channels to protect the wires during handling.

11
12 The head suspension and slider assembly described herein
13 incorporates a stiff load beam and a relatively long and narrow
14 flexure which includes thin weak flexure legs and connecting
15 lateral part. With this design, low bending stiffness and high
16 lateral and longitudinal stiffness with low roll and pitch
17 stiffness are realized. The load beam tongue has a high vertical
18 or perpendicular stiffness so that there is minimal bending of
19 the load beam tongue up or down relative to the plane of the
20 suspension. The first bending mode resonant frequency or
21 vibration is substantially higher than known prior art suspension
22 designs of comparable size.

23
24 In an actual implementation of this invention, the overall height
25 B of the slider is about 0.0110 inch, its length about 0.0400 inch,
26 L and its width about 0.020 inch. The height of the step 28 is
27 about 0.0015 inch above the recessed portion 30 which is 0.0336
28 inch long. The surface area of the top of the step 28 is
29 preferably minimized in size to reduce the effects of bending or
30 warping at the surface of the slider step which may occur due to
31 the difference in the thermal coefficients of expansion of the
32 ceramic slider 22 and the stainless steel ear 38. Such bending
33 would affect the flying characteristics of the head adversely.

34
35 In an alternative embodiment of the head suspension, illustrated

14
1 in part in Figs. 6A-7, the flexure section 62 is formed with a
2 tongue 64 and a cutout 66. A down-facing load dimple 76 is
3 provided on the tongue 64. Narrow etched legs 68 that extend
4 from the load beam 10 are connected by a transverse part 70. The
5 legs 68 are chemically etched to be thinner than the integral
6 flat piece used to form the load beam and flexure sections.
7 Outriggers 72 forming a split tongue are provided at the sides of
8 the flexure 62 and are separated from the thin legs 68 by cutouts
9 74. The outriggers 72 overhang the sides of the slider 22 and
10 the slider is fastened to the outriggers by an adhesive fillet
11 90. In this implementation, the top non-air bearing surface 20
12 of the slider 22 is bonded to the outriggers 72. The slider 22
13 is mounted to the outriggers 72 so that the center of the slider
14 is aligned with the load dimple 76, and the slider projects
15 beyond the end of the transverse part 70. There is no offset of
16 the load dimple 76 relative to the centerline of the slider.
17 With this implementation, a lower vertical height (Z-height) is
18 realized. Also the slider bonding areas of the outriggers 72 are
19 larger than the bonding area of the lateral connecting part 38 of
20 flexure 12 of Fig. 1. In this implementation, there is little
21 room to move the slider toward the leading edge relative to the
22 load dimple, which may be necessary to obtain optimal flying
23 attitude. Also, additional forming is required in order to bend
24 the two outrigger legs 72 down to the bend 20, which increases
25 the tolerances during production.

26
27 Fig. 8 shows a paddleboard or fret 80 formed from a stainless
28 steel piece that has been stamped with a number of head
29 suspensions 82, each of which was formed with the design shown in
30 Fig. 1. Tooling holes 84 and support legs 86 are provided for
31 further handling. Fig. 8A shows the paddleboard 80 with support
32 legs 86 bent to enable working on the extremely small femtoslider
33 suspensions.

34
35 Fig. 9 shows a nanoslider suspension such as disclosed in

FB

1 compending application Serial Number 07/926,033. The nanosl原因der
2 includes a load beam 94, flexure 96, load beam tongue 98, spring
3 section 100, rear mount section 102 and slider 104.

4
5 Figs.10 and 11 illustrate the femtoslider suspension of this
6 invention with the load beam 10, flexure 12, spring section 56
7 and a rear section having a tooling hole 106. The tooling hole
8 section 106 is attached to an extension 108 formed with an
9 apertured swage 110 that allows attachment to a rotary actuator.

10 B In effect for extremely small drives, such as 1.3 inch and
11 smaller, the extension 108 serves as an arm pivot and precludes
12 the need for a separate arm structure, as used in the prior art.
13 The extension 108 also allows the assembly to match the overall
14 B length of other industry standard "70%" microslider suspensions,
15 thereby making it easy to use existing tooling.

16
17 Fig. 11 shows the suspension skewed with relation to the
18 extension 108 to compensate for skew experienced as the head
19 moves between the outer diameter and the inner diameter of the
20 disk during accessing. The extension may include apertures 112
21 for weight reduction, as shown in Figs. 10 and 11. The apertures
22 112 serve to adjust for resonant conditions and/or to adjust for
23 total actuator balance about the pivot.

24
25 B Fig. 12 illustrates the femtoslider^{suspension} without the extension and
26 shows the large difference in size between the nanosl原因der and
27 ~~femtoslider~~^{femtoslider} suspensions. In an implementation of the
28 B femtoslider, the length was about 0.395 inch and the greatest
29 width was about 0.056 inch.

30
31 P By virtue of this invention, a single integral piece is formed
32 with a load beam and flexure, thereby realizing a significant
33 savings in material and labor. Alignment of the load beam and
34 flexure and welding of the separate parts are eliminated.
35 Certain critical tolerances that were required in former load

1 beam/flexure assemblies are no longer needed thereby enhancing
2 the assembly process. The design allows the separation of the
3 load transfer function from the gimbaling action which eliminates
4 the weak bending characteristic found with prior art suspensions.
5 It should be understood that the parameters, dimensions and
6 materials, among other things, may be modified within the scope
7 of the invention. For example, the slider design with the step
8 and platform configuration disclosed herein can be used with a
9b "50%" nanoslider suspension or other size suspensions.

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26 CM What is claimed is:
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